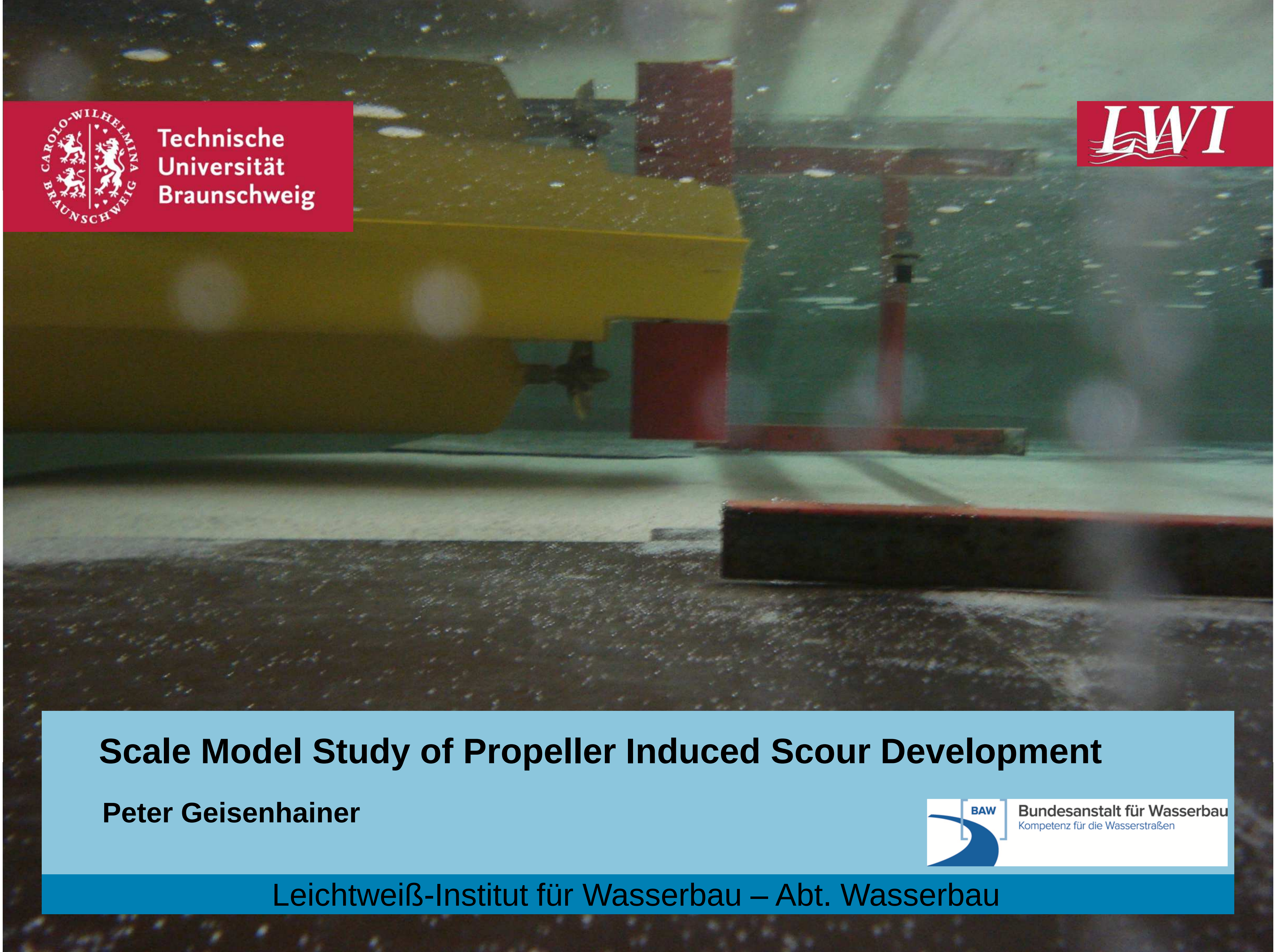

Technische Universität Braunschweig

LWI

Scale Model Study of Propeller Induced Scour Development

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Overview

- Motivation and aim
- Model setup
- Experiments
- Results of performed experiments
- Outlook

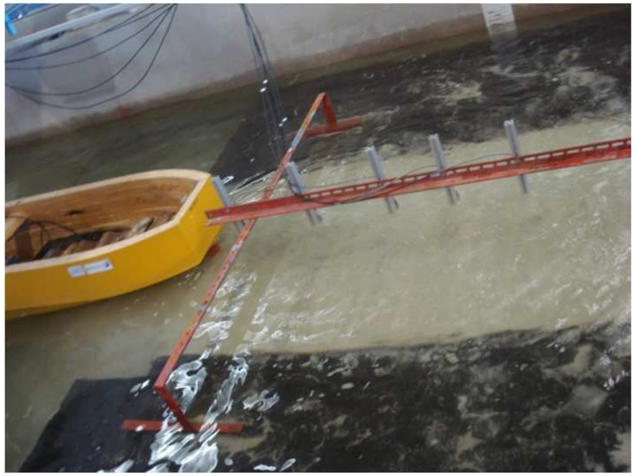
Motivation and aim

- Motivation
  - Lack of general formula to determine scour depth
  - Increased transport volume on rivers and canals → higher loading larger motor power → higher stress on the river bed → larger scours

Prototype experiment in a groine field of the River Rhein, 1975

Motivation and aim

- Aim
  - Improvement of the understanding of scour process induced by propeller jets
  - Extension of an existing data base
  - Formulation of a formula to determine the scour depth development $\varepsilon(t)$



Motivation and Aim

- Problem

$$\varepsilon = f\left(D_P, K_T, A_{blade}, n, h_P, h, \rho, \mu, \rho_s, d, \sigma, \phi, g, t\right)$$

Scour development depends on

- Ship properties
- Hydraulic conditions
- Sediment properties
- Acceleration of gravity and time

Fuehrer et al. (1981) $\frac{u_{b,max}}{u_0} = E\left(\frac{h_P}{D_P}\right)^{-1}$

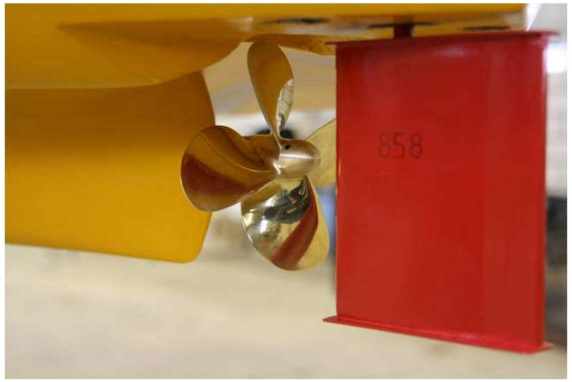
where $u_0 = f\left(n, D_P, K_T\right)$ BAW (2004)

Model setup

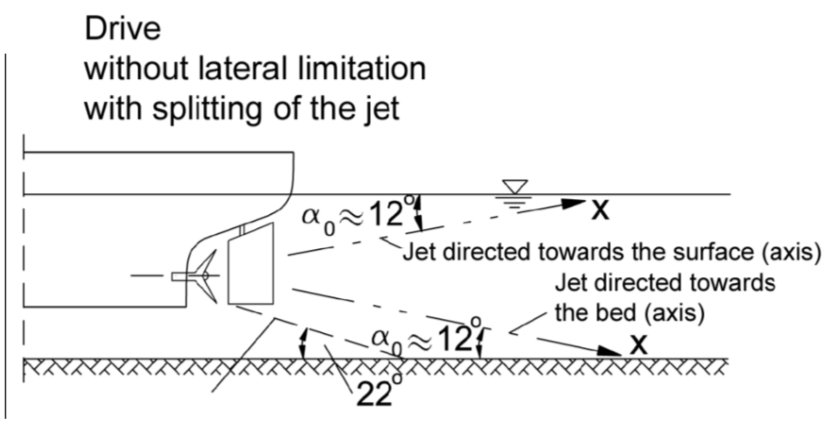
- ship model „Bea W.“
  - motor-driven stern model
  - scale 1:16 „Großes Rheinschiff“
  - 5 m long, 70 cm wide und 40 cm deep

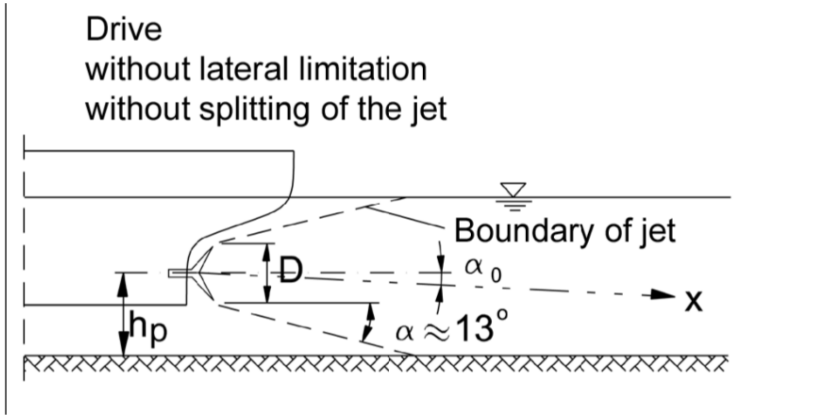
Model setup

Wageningen-Propeller with central rudder



Kaplan-Propeller with Kort nozzle and double rudder





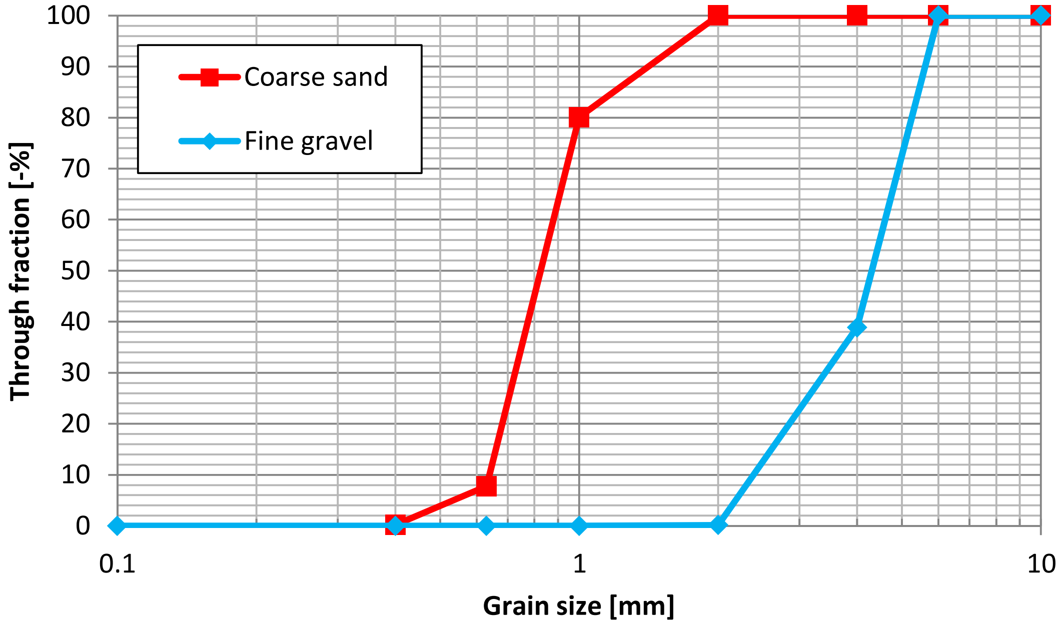
(BAW, 2005)

Model setup

- Test station
  - basin 3,5 m wide, 15 m long und 1,25 m deep
  - two areas
    - fixing and parking area
    - sediment bed

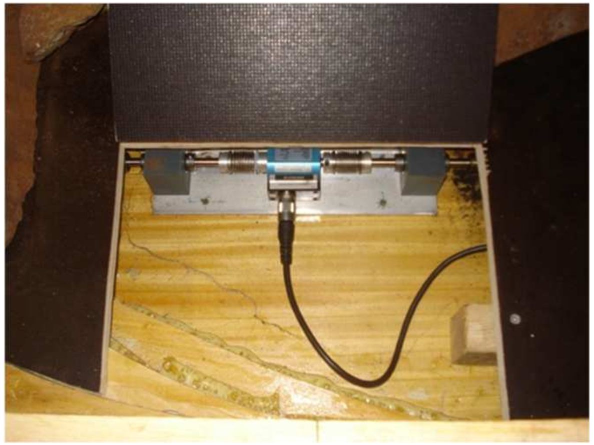
Model setup

- Sediments
  - Uniform material
  - Sand (d_{50} = 0.8mm, ϕ = 33°)
  - Gravel (d_{50} = 4.2mm, ϕ = 33°)



Model setup

- Measuring techniques
  - 5 supersonic sensors
    - Temporal detection of the scour depth development of a point ($\varepsilon(t)$)
  - Force measuring unit (thrust S)
  - Torque measuring (torque M_T und number of revolultions n)



Experiments

- Two kinds of tests
  - Maneuvering – fixed ship (already performed)
  - Start situation – moving ship (not yet performed)
- Two test groups
  - Group 1 – sand
  - Group 2 – gravel
  - Variation of the following parameters in each main group

    Propulsion system

    Draught T

    Water level h

    Number of revolutions n
- Further tests (without hull etc.)

Experiments

Three different experimental strategies

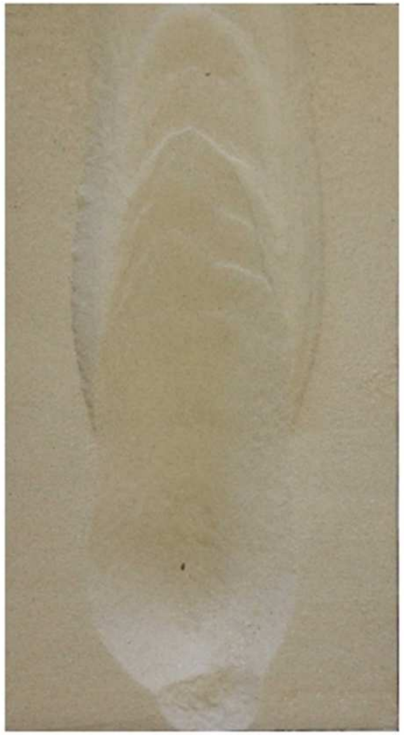
- Interval tests → interested in scour development

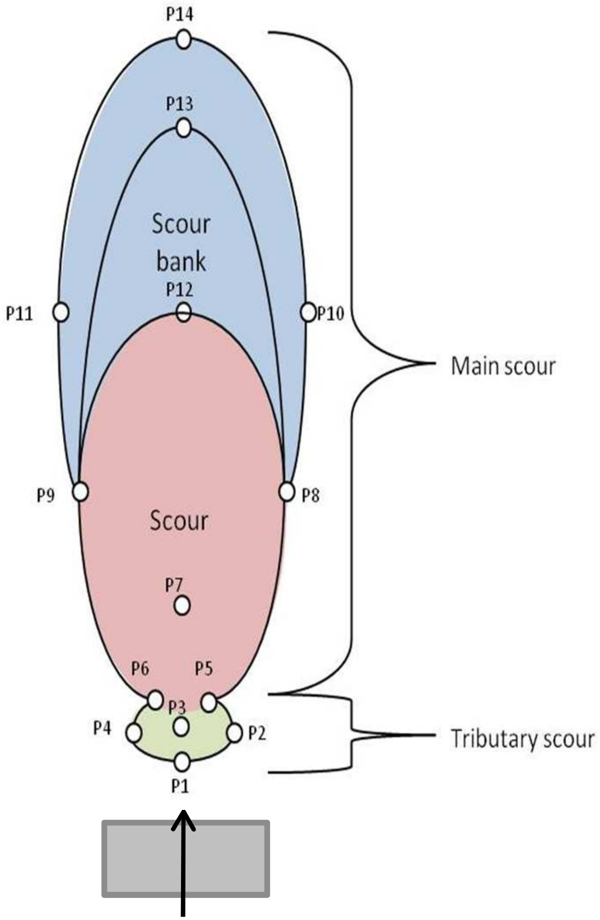
Interval	Duration [s]	Total test duration [s]	Total test duration [min]
1	10	10	0:10
2	20	30	0:30
3	40	70	1:10
4	80	150	2:30
5	160	310	5:10
6	320	630	10:30
7	640	1270	21:10
8	1280	2550	42:30
9	2560	5110	85:10
10	1050	7200	120:00
11	2970	10230	170:30

- Permanent tests → performed to investigate an influence caused by interruption
  - Different test durations without interruptions, e.g. 5min, 2h, 24h
- Long term tests (24h) → performed to “reach” the equilibrium scour depth

Experiments

- Survey of characteristic scours
  - By hand, because scanner was not available

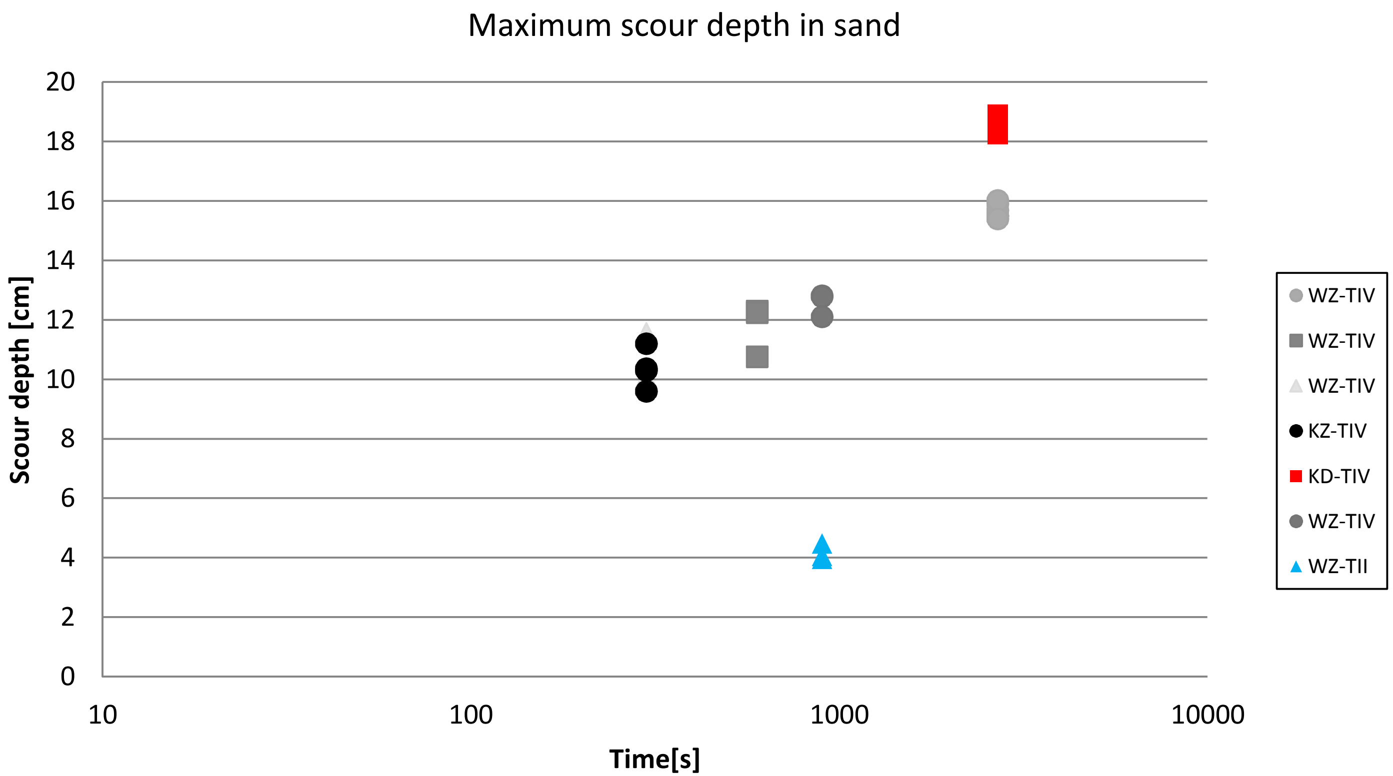




P1:	Start of tributary scour
P2:	Port side of tributary scour
P3:	Deepest point of tributary scour
P4:	Starboard side of tributary scour
P5:	Port side of transition to main scour
P6:	Starboard side of transition to main scour
P7:	Scour depth ε
P8:	Beginning of scour ridge (port side)
P9:	Beginning of scour ridge (starboard side)
P10:	Port side of scour ridge
P11:	Starboard side of scour ridge
P12:	Beginning of scour ridge
P13:	Scour ridge height
P14:	End of scour ridge

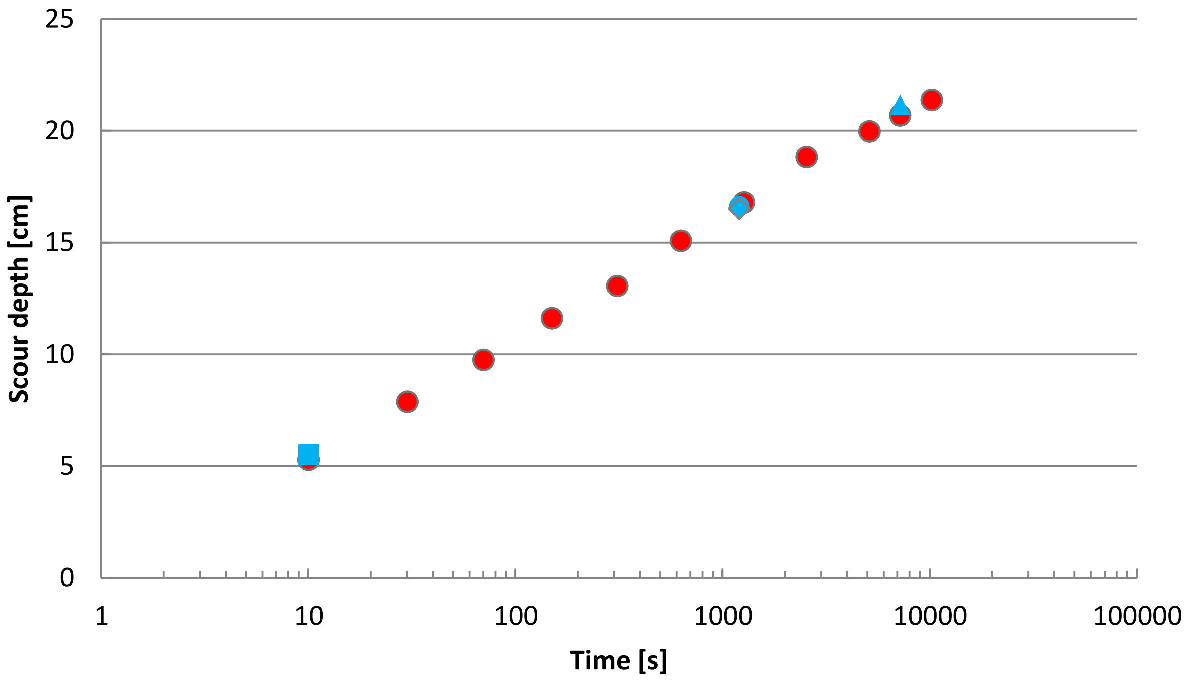
Results – reproducibility

- Deviations 8 % of the mean value
- Reproducibility of tests is given



Results – influence of interval measurements

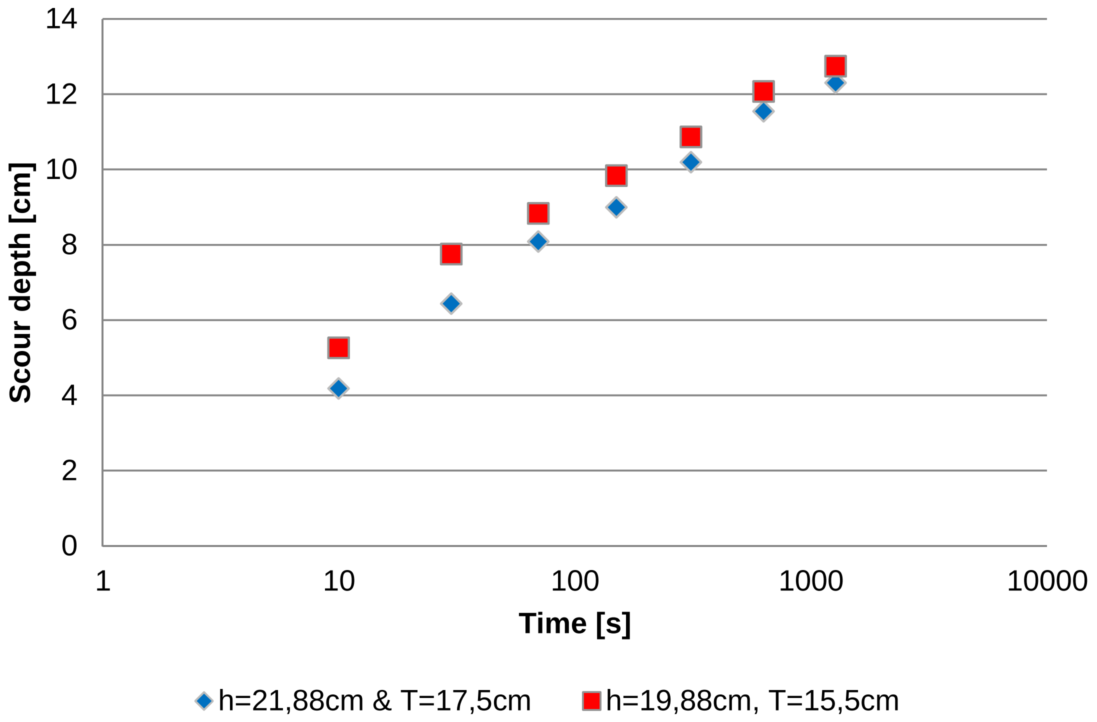
- Influence of interval measurements not recognizable



Kaplan propeller + Kort nozzle and double rudder in gravel

Results – influence draught and water level

- Development of scour depth depending on h and T



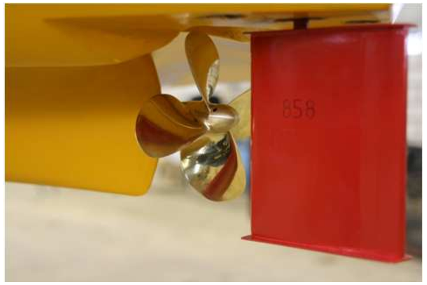
Wageningen Propeller and central rudder in sand

Results – symmetry

- Shape of scour depending on kind of propulsion unit

Wageningen-series B propeller with central rudder

Kaplan propeller with Kort nozzle and double rudder



Results – Tributary scours

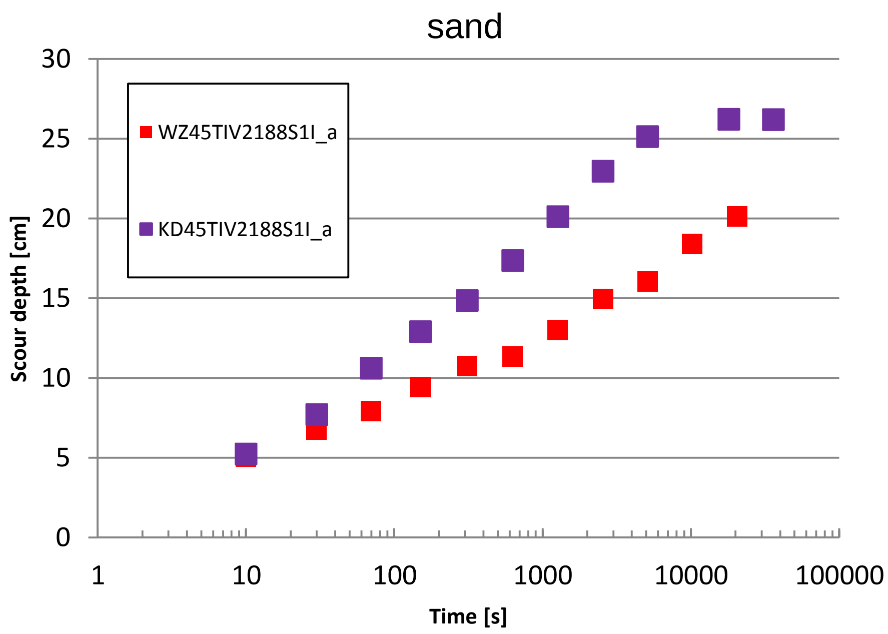
- occurred already in other experiments
- no consideration for the calculation of scour depth

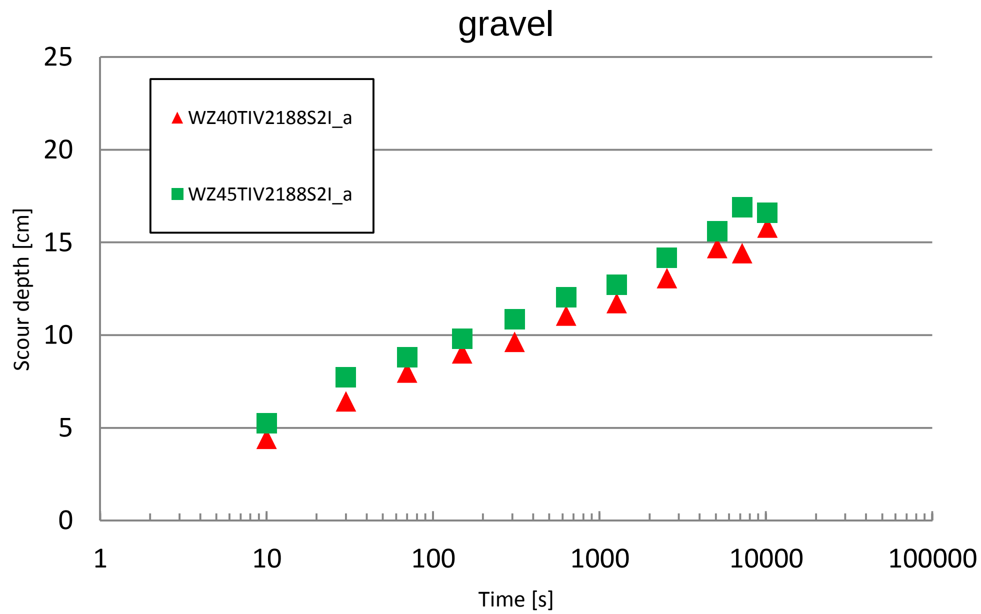
Twin-propeller (Felkel, 1975)

Wageningen B-series propeller and central rudder

Results – scour depth

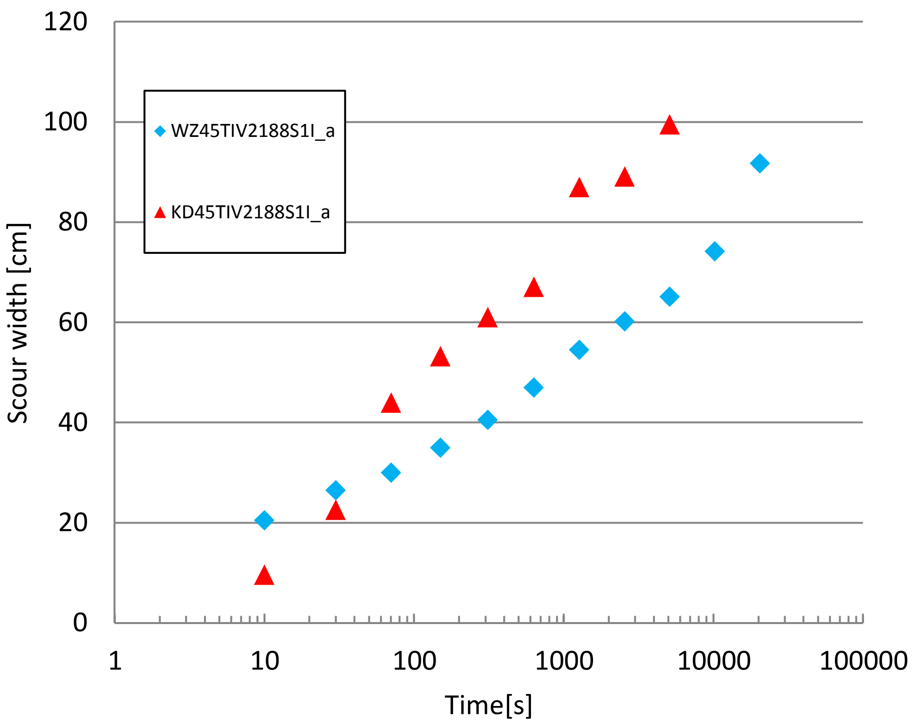
- in coarse sand deeper than in fine gravel
- depending on the induced near bed velocity u_b due to rpm
- scours caused by Kaplan propeller deeper than for Wageningen propeller (unexpected, Fuehrer and Römisch (1988))



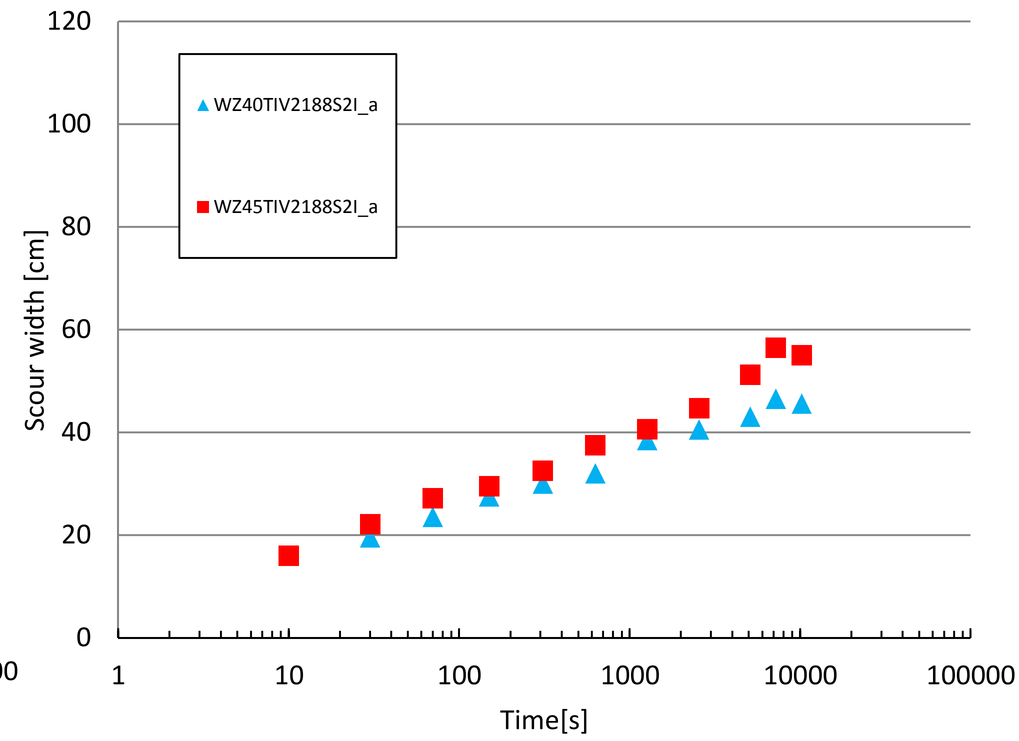


Results – scour width and length

- in sediment 1 wider than in sediment 2
- wider for Kaplan propeller than for Wageningen propeller
- same behaviour of development regarding scour length



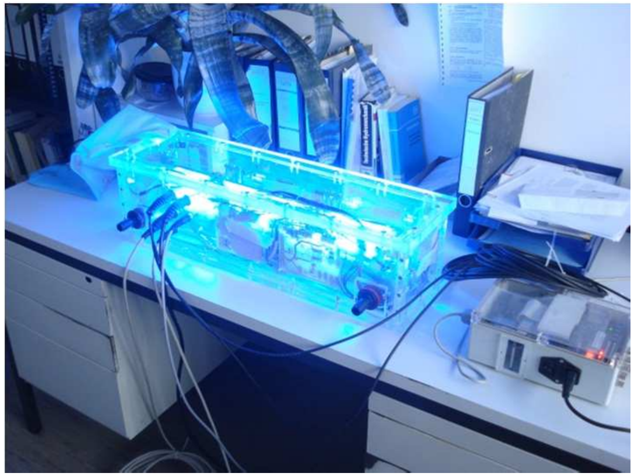
sand

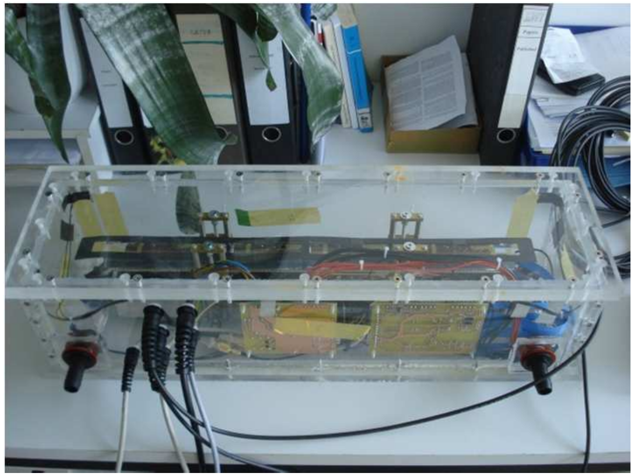


gravel

Outlook

- investigation of the velocity field within the propeller jet
  - clarification “Why are scours caused by Kaplan propeller deeper than ones caused by Wageningen propeller?”
  - conclusion to near bed shear stress τ
- investigation of the scour development caused by moving ships





Thank You For Your Attention